(54) Title: INFORMATION CONTROL SYSTEM

FIG. 1
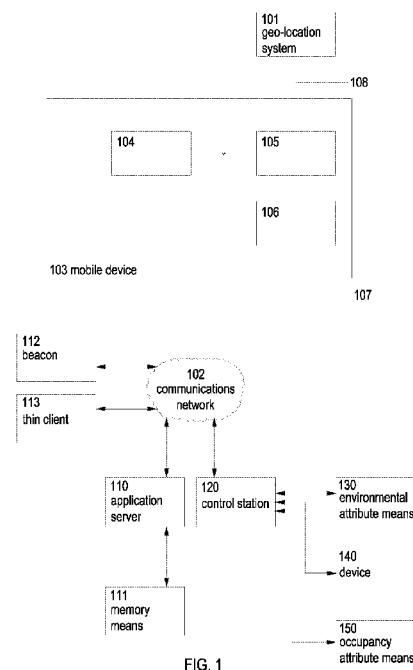
(57) Abstract: A system and method is used to characterize a user with properties, such as location in relation to established geo-fences, speed of traverse, projected traveling time required for a particular distance, etc. Those properties contribute to yielding a quantitative result in the calculated lead time period prior to the user arriving at a monitored space, including but not limited to a rented room in a hotel, and a house. The method uses the user's arrival time to estimate the setback temperature, which is the indoor temperature of a monitored space maintained during unattended time periods. The method also uses the user's arrival time to estimate the heated water volume to be provided, as well as, to house watch other property management interests.

INFORMATION CONTROL SYSTEM

Technical Field

[1]   The present invention relates to a user location tracking system ('tracking system') and methods to locat e user carried mobile devices , such as those used in digital cellular systems, personal communications systems (' PCS '), enhanced specialized mobile radios (' ESMRs '), radio frequency ('RF') based tracking systems (Bluetooth, WiFi), and other wireless communications systems. More particularly, but not ex- clusively, the present disclosure relates to methods that employ the location of the indi- vidually tracked user to determine the time at which the user arrives ('arrival time') at a monitored space, including the corresponding rented room at a hotel ('rented room'), and the total number of tracked users at a monitored space for control of the related conditions.

Background Art

[2]   A residing guest ('user') at a hotel contributes to energy consumption in the use of a rented room through two primary utility sources: H eating, V entilating and A ir -C on- ditioning system ('HVAC') and heated water. In c onventional HVAC systems, the temperature within a rented room is raised or lowered at multiple operating levels. The indoor temperature is typically maintained at three different levels. The setpoint level is often selected by the user when the rented room is attended. The comfort level is maintained at a few degrees from the setpoint temperature for energy conservation when the rented room is unoccupied while allowing speedy resume to the setpoint level. The free level is used for maximal energy conservation of an unrented room. In furtherance, housekeeping services are preferably provided to the rented room during guest unattended moments. Other services such as control of devices and security pertaining to a monitored space are currently enacted with other automation systems.

Disclosure of Invention

Technical Problem

[3]   Common problem of the comfort level of a monitored space often being th e se tback temperature either too far away from the setpoint temperature to provide satisfactory comfort when someone returns to the rented room, or too close to the setpoint tem- perature to achieve adequate energy savings. Indoor temperature at comfort level requires a drive time to be resumed to setpoint temperature; the corresponding estimated minimal required drive time is therefore overly inaccurate. The 'Short Cycling' phenomenon may result from insufficient operating times, leading to over- shooting the user's setpoint temperature and unbounded up/down temperature cycles

within a given time period. The result is unavoidable damage to the HVAC system and shortening of the general operative life span.

[4]   Heated water at setpoint temperature must also be readily supplied to the monitored space . Water heaters fall into one of two categories: 1. tankless type water heaters, and 2. storage tank type water heaters. Consumption of heated water greatly varies with in different times of the day and during different seasons of the year notwithstanding, the volume is also dependent on the number of users being onsite . Should the heated water supply be planned on basis of the projected number of users being at the monitored space during the day, the volume of heated water allocated on the per user basis can be maintained at an interrelated level.

[5]   In addition, the devices within a monitored space are not restricted for use of intended users. Home appliances are largely automated through programmed config-urations and distant control, but are unable to respond in accordance with user identi-fication.

Technical Solution

[6]   The present invention provides a system and methods to determine the user's arrival time at an unoccupied monitored space for determination of the setback temperature, the quantity of heated water consumption, scheduling of service provisions. The operative modes of devices related to the monitored space are changed in accordance with detected or expected presence of intended users.

Advantageous Effects

[7]   The setback temperature of the unoccupied monitored space can be drifted to the farthest level from the user configured setpoint level, and is driven to the setpoint level in accordance with the system determined arrival times of one or more users. The quantity of readily supplied heated water is drifted and driven in accordance with expected number of users remaining or arriving in the monitored space. Maximal energy savings can be achieved. In furtherance, change of operative modes of devices related to the rented room with restriction to intended users, not only enhances user ex-perience, it also renders strengthened security.

[8]   In various aspects, a system is disclosed for locating and recording with respect to time a proximity log related to location of a user carried mobile device encompassing one or more transmitters for wireless communication. In one embodiment, said mobile device is further equipped with location analysis functionality and selectively transmits a message encompassing the proximity log on its location relative to a predetermined geo-fence area. The system includes an application server that receives the message and determines the user's arrival time at the rented room . In furtherance, the ap-plication server proceeds with the calculation of the total number of tracked users with

respect to time during the day. In a further aspect, the control station sends obtained attributes to the application server, and controls connected attribute station and external devices in accordance with received proximity logs sent from the application server. The control station includes but not limited to a Building Management System , and a gateway with internet and WLAN connectivity .

[9]   In one embodiment, the application server estimates the drive time of temperature response in a HVAC controlled room by the following steps: obtaining the indoor temperature at a beginning point, intermediate points and an end point of the prior drive operation; calculating a drive curve using the beginning, intermediate and end temperatures; and using the drive curve to estimate a time at which the desired temperature will be reached. In an alternative embodiment, estimating the drive time may comprise the steps of: obtaining a plurality of indoor temperature data samples over a period of time corresponding to the prior drive operation; calculating a plurality of drive curve sections, each section calculated using a subset of data samples; conjoining all calculated drive curve sections.

[10]   In another embodiment, a method for calculating the quantity of heated water consumption during the day. The application server projects the daily peaks of actual water consumption by utilizing the consumption rate versus time on basis of historic operations, composing a curve of the daily consumption rate versus time, and using the projected number of users at the hotel on basis of a plurality of received proximity logs, and therefore the arrival times of tracked users, to project the time at which the daily peaks of heated water consumption will be reached.

[11]   In a further embodiment of the method, the application server estimates the time duration of each rented room being in an unoccupied status and composes a schedule of housekeeping service in priority. The dynamic information is stored in a server connected memory means. In yet a further embodiment of a method for determining and setting the operative modes of selected devices related with the rented room, on the basis of the concurrent user location and in accordance with preset operating parameters or user authorization.

Description of Drawings

[12]   The drawings constitute to embodiments of the present invention and serve to depict the apparatuses infrastructure and operating principles.

[13]   FIG.1 is a block diagram representation of the present invention of the tracking system.

[14]   FIG.2A depicts a traveling trace of user carried mobile device with respect to a polygonal geo-fenced area.

[15]   FIG.2B depicts the locations of user carried mobile device at different instantaneous times with respect to a circular geo-fenced area.

[16]   FIG.3 is a graph depicting the calculated thermal drift & drive relationships within a monitored space, using a non-linear equation.

[17]   FIG.4 is a graph depicting the thermal drift & drive relationships within a monitored space, identifying recorded data samples over a period of time.

[18]   FIG.5 is a flow chart depicting a method to calculate setback room temperature settings, and the projected heated water consumption quantity, using the user location and projected user's arrival time at a hotel.

[19]   FIG.6A is a graph depicting the historic heated water consumption rate on an average day at a hotel.

[20]   FIG.6B is a graph depicting the recorded heated water consumption rate, and projected heated water consumption rate based on a plurality of projected users' arrival times at a hotel.

[21]   FIG.7A depicts a schedule for allocating human resources in service provisions with prioritization in accordance with rented room users' arrival times.

[22]   FIG.7B is a flow chart depicting a method to house watch a monitored space.

Best Mode

[23]   The present invention may be better understood with reference to embodiments depicted by supporting drawings, however, it is not intended that the invention be restricted to those depicted embodiments. Those skilled in the art will recognize that variations and modifications can be made without departing from the true scope of the invention as defined by the claims. It is therefore intended to include within the invention all such variations and modifications as fall within the scope of the appended claims and equivalents thereof.

[24]   FIG.1 illustrates the present invention in environment **100**, in which certain preferences in geo-fence details, operating parameters and controls information are selectively sent from application server **110** to mobile device **103**. Mobile device **103** is enabled to transmit preferred messages to application server **110** for data logging. Application server **110** performs projection of the arrival time at the rented room of the user carrying mobile device **103**. At any time , the user can send a m anually entered arrival time through mobile device **103** to application server **110**.

[25]   Geo-location system **101** is a terrestrial or satellite based positioning system; some of which include but not limited to the Beidou Navigation System , Differential GPS (' DGPS'), Eurofix DGPS, Global Positioning System ('GPS'), pertaining to the Global Navigation Satellite System ('GNSS'). In other types of positioning systems, geo-location system **101** comprising cellular communication towers, or other systems provid ing reference points , transmit RF signals that are received by mobile device **103** .

[26]   Mobile device **103** encompasses embedded device **104** (e.g. an onboard computer

with memory means (not shown) and limited functionality), geo-receiver **105**, telematics device **106** and the corresponding antennae **108, 107**. Embedded device **104** is wirelessly loaded with operating parameters, which include but not limited to the geo-fence boundary definitions, the clock time, and the polling interval, etc. Mobile devices **103** include a cellular phone, and a handheld device possessing wireless communication connectivity, such as a tablet computer, and the like.

[27]   Typically , geo-receiver **105** processes geo-location system **101** sent signals received by antenna **108**, for obtainment of the con current location of mobile device **103**. In one embodiment, mobile device **103** determine s its location by engaging in the trilateration process. Telematics device **106** transmits to application server **110** via antenna **107** - at constant or variable specific frequency in time as per the preconfigured polling interval - coded wireless messages comprising the present location and a unique identi fier of mobile device **103**. In an alternative embodiment , mobile device **103** transmits to application server **110** by telematics device **106** via antenna **107** said coded wireless messages at a defined polling interval in accordance with received application server **110** sent periodic probe requests.

[28]   Application server **110** receives information encompassing the mobile device **103** location and unique identifier via network **102**. Application server **110** executes a program which calculates the lead time period pertaining to the user's arrival time at the related rented room . Alternatively, application server **110** assigns a predefined lead time period on the basis of the geo-fenced area - related to a geo-fence boundary - in which mobile device **103** is located. The lead time period and the operating parameters of mobile device **103**may be changed in accordance with change in the mobile device **103**located geo-fenced area. Application server **110** may be any equipment capable of facilit ating two way communications with telematics device **106**on mobile device **103**. In another embodiment, mobile device **103** calculates the lead time period pertaining to the user's arrival time at the related rented room; it sends the most updated proximity log - encompassing at least the calculated lead time period and the unique identifier to application server **110** in said coded wireless messages.

[29]   A library of predefined geo-fence boundaries, the polling interval at constant or variable frequency directing data logging between application server **110** and mobile device **103**, quantitative calculations performed by application server **110** , and other information such as personal data of the user, is stored in memory means **111** and retrieved by application server **110** via a wired or wireless communicative network. Memory means **111**, working with or within application server **110** , can be any device, including magnetic, optical or solid-state memory ; where stored information can be changed via a communicatively connected thin client **113**.

[30]   In an outdoor environment for use with geo-location system **101**, network **102** uses a

combination of wireless and landline communication infrastructure such as a cellular telecommunication system and the internet, provides two-way data logging between telematics device **106** and application server **110** .

[31]   On the other hand, the wireless and landline communication infrastructure of network **102** pertinent to an indoor tracking system, as depicted in FIG.1, typically encompasses a combination of WLAN/Ethernet. Wherein, user carried mobile device **103** possessing Bluetooth communicative components and functionality is continually tracked through a node based mesh network (not shown) constructed on basis of a plurality of Bluetooth beacons **112**. Bluetooth beacon **112**transmits a signal to mobile device **103** in the indoor environment, and transports the returning signal to the communicatively connected application server **110**. Operatively similar to said outdoor tracking system, the proximity log encompassing the lead time period pertaining to the user's arrival time at the related rented room is obtained by application server **110** on basis of the position of mobile device **103** .

[32]   Referring to FIG.2A, geo-fenced area **203** is the area within a polygonal geo-fence boundary **204** . The geo-fenced area **203** has a center-of-mass **20 1** , and a computed circular approximation **205** with radius **20 2** , corresponding to the maximum offset between the computed center-of-mass **201** and the furthest edge of geo-fence boundary **204**. The dotted trace **22 0** depict s an ex e mpl ary path of mobile device **103** cross ing geo-fence boundary **204** and traveling away from center-of-mass **201**, being the related rented room at a hotel, as in one embodiment.

[33]   In FIG.2A, a zone of Level 0 is defined as an area beyond circular approximation **205** : a zone of Level 1 may be defined as the area within circular approximation **205** . Application server **110** can alter the shape of geo-fence boundary **204** within zone Level 1 , in accordance with preconditioning factor s pertinent to traffic conditions, time of the day, the unique identifier of mobile device **103** and characteristics of the user or the related rented room, etc.

[34]   In one embodiment, application server **110** correlates the data pertinent to the real-time location of the user carrying mobile device **103** to a preconfigured lead time period Δt_a , which is the time period between the concurrent time and the projected user's arrival time at center-of-mass **201**. For instance, a preconfigured value is assigned for lead time period Δt_{a1} when mobile device **103** is at position **211**, and within the geo-fenced area **203** ; another preconfigured value is assigned for lead time period Δt_{a2} when mobile device **103** is at position **212**, which is outside geo-fence boundary **204** .

[35]   Referring now to FIG.2B, illustrated is geo-fenced area **253** pertaining to circular geo-fence boundary **254** . G eo-fence boundary **254** having radius **252** has been defined around central point **251** , being the rented room at the hotel , as in one em-

bodiment . The dotted trace **22 1** depict s an ex e mpl ary path of mobile device **103** cross ing geo-fence boundary **254** and traveling toward central point **251**. A zone of Level 0 is defined as an area outside geo-fence boundary **254**: a zone of Level 1 i s the area within geo-fence boundary **254**. Application server **110** can alter the coverage of zone Level 1 withingeo-fence boundary **254**, in accordance with preconditioning factor s pertinent to traffic conditions, time of the day, the unique identifier of mobile device **103** and characteristics of the user or the related rented room, etc.

[36]   In an alternative embodiment, application server **110** correlates the data pertinent to the real-time location of mobile device **103** to a mathematical calculation of lead time period Δt_a , as follows:

[37] $\Delta t_a = \gamma \cdot d / v$ [1]

[38]   where Δt_a is the lead time period between the concurrent time and the projected user's arrival time at the rented room of central point **25 1** ; γ represents a pre-configured factor pertinent to the uncertain preconditions affecting lead time period Δt_a , such as time of the day, the unique identifier of mobile device **103** and charac-teristics of the user or the related rented room, etc .; d is the distance between the concurrent location of the monitored mobile device **103** and central point **25 1** ; v is the user's velocity of travel, which may be calculated, using:

[39] $v = (d_2 - d_1) / (t_2 - t_1)$ [2]

[40]   where v, is periodically calculated on basis of the time difference to travel from one location to another. For instance, v is indicated by the difference between d_1 (traversal distance between first position **261** and central point **25 1**), and d_2 (traversal distance between second position **262** and central point **25 1**), divided by the difference of t_1 (instantaneous time recorded at first position **261**), and t_2 (instantaneous time recorded at second position **262**). O ther formulae and methods may seem fit in different situations where appropriate and therefore can also be applied for calculation of lead time period Δt_a . Application server **110** performs the calculations and sends the calculated values of lead time period Δt_a to control station **120** and other systems.

[41]   Those skilled in the art will appreciate that the exemplary methods disclosed herein may be applied to any geo-fenced area represented by any number of shapes and sizes. A geo-fence around a center of mass may range in complexity from a line to a highly irregular shape which more accurately follows the landscape of the hotel premises and neighborhood. There are a number of methods for constructing these geo-fences which will be apparent to one skilled in the art.

[42]   Thermal Drift & Drive Relationships

[43]   FIG .3 illustrates an exemplary temperature change in an indoor space, wherein t he outdoor temperature is lower than indoor setpoint temperature T_{set} of the space. A mbient temperature T_{amb} is the temperature at which indoor temperature T (t) will theo-

retically reach in accordance with indefinite increase in time t, when the HVAC heating operation is off; it is at a constant level in this case for demonstration purposes.

[44]   Drift curve **300 -1** represents the 'drift process' of indoor temperature T(t) with respect to time, beginning at a rapid rate decreasing from setpoint temperature T_{set} as indoor temperature T(t) approaches the steady-state temperature, which is substantially the same as ambient temperature T_{amb} . Drive curve **300 -2** represents the 'drive process' of i ndoor temperature T(t) of the space being driven from ambient temperature T_{amb} up to setpoint temperature T_{set} in relation to time during a HVAC heating operation. The drive rate is decreasing as i ndoor temperature T(t) approaches setpoint temperature T_{set} . T he required time period to drift indoor temperature T(t) from one level to another varies in accordance with time and season, as well as other factors such as the weather and energy sinks within the space. In contrast, drive curve **300-2** is dependent on the unique space environment, and HVAC system performance. The data pertaining to the relationships between temperature responses to HVAC operation must be obtained to project the time period for indoor temperature T (t) to drift from one point to another, as well as the time to drive indoor temperature T (t) from one point to another. For a cooled room on a warm day, the principles are the same, yet the direction s of in-creasing temperature on the y-axis would be inverted.

[45]   In one embodiment, mathematical functions may be used to describe the temperature responses through drift c urve **300 -1** and drive c urve **300 -2** . In an exemplary use case, Newton 's Law of Cooling is used for calculation of the drift and drive per-formances. The rate of change of indoor temperature T(t) over time dT/dt , is pro-portional to the difference between indoor temperature T(t) and ambient temperatur e T $_{amb}$. A differential equation is used in a mathematical form, as follows:

[46] S dT / (T - T_{amb}) = k · S dt [3]

[47]   where indoor temperature T(t) corresponds to a drift process from setpoint tem-perature T_{set} to ambient temperature T_{amb}. Solving the differential equation,

[48]   we yield an equation having indoor temperature T(t) as a function of time :

[49] $T(t) = T_{amb} + (T_{set} - T_{amb}) e^{-kt}$ [4]

[50]   where k is a constant dependent on the surrounding environment within the space. Having measured indoor temperature T(t) at any time t, and knowing ambient tem-perature T_{amb} , the value of k can be easily sorted .

[51]   In an alternative embodiment, application server **110** obtains ambient temperature T $_{amb}$, indoor temperature T(t) pertaining to the drift and drive data from environmental attribute means **130**, records, and stores the data in memory means **111**. In yet another embodiment, application server **110** receives a data feed from control station **120** , or other external sources, comprising drift and drive data of indoor temperature T (t), and ambient temperature T_{amb}. Calculations, data recording andexternal information source

pertaining to obtainment of drift data, drive data and ambient temperature T_{amb}, can be continually processed, stored in memory means **111**, and used for studying indoor temperature $T(t)$ responses versus time t during a HVAC cooling or heating operation in a space.

[52]   FIG .4 illustrates an exemplary indoor temperature $T(t)$ response in accordance with drift curve **4 00 -1** and drive c urve **4 00 -2** . Dotted curve **400 -3** of the fluctuating a mbient temperature T_{amb} varies in compliance with outdoor temperature changes during the day.

[53]   Setback temperature T_{sb} is a temperature level of an unoccupied rented room maintained by a HVAC system, which is intended to resume to setpoint temperature T_{set} within a short time after user entry. The required time to drive setback temperature T_{sb} to setpoint temperature T_{set} is recovery time period Δt_r - which is dependent on the HVAC system capacity. It is better expressed as :

[54] $\Delta t_r = t_{set} - t_{sb}$ [5]

[55]   where t_{set} is the time at which indoor temperature $T(t)$ is driven toward setpoint temperature T_{set}; t_{sb} is the starting time of the drive process, at which indoor temperature $T(t)$ equals to setback temperature T_{sb} .

[56]   In one embodiment, application server **110** calculates recovery time period Δt_r on the basis of the obtained user's arrival lead time period Δt_a , then extrapolates the corresponding indoor setback temperature T_{sb} , based on the relationships between the temperature responses and time in a drift process and a drive process. Attention is drawn with care to make sure that r ecovery time period Δt_r should be within lead time period Δt_a to complete drive of setback temperature T_{sb} to setpoint temperature T_{set} :

[57] $\Delta t_r \leq \Delta t_a$

[58]   Or,

[59] $\Delta t_r = \alpha \cdot \Delta t_a$ [6]

[60]   where α represents a preconfigured factor mathematically describing the uncertainty affecting lead time period Δt_a . In another embodiment, recovery time period Δt_r is also expressed as:

[61] $\Delta t_r = r \cdot | T_{set} - T_{sb} |$ [7]

[62]   where recovery rate r (expressed in unit time per unit temperature, such as seconds per °C) is the rate for the HVAC system to drive i ndoor temperature toward setpoint temperature T_{set} . Recovery rate r is calculated as follows:

[63] $r = (T_{set} - t) / | T_{set} - T(t) |$ [8]

[64]   where $T(t)$ is the indoor temperature of the space during any time t.

[65]   Data encompassing recovery rate r in relation with a mbient temperature T_{amb} can be stored in memory means **111** . Any technique of calculating and combining the most recently calculated recovery rate r and a n archived recovery rate r can also be utilized

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[66]   Other than recovery rate r yielded by equation [8] or others, the manufacturer of the HVAC system also provides the recommended recover rate r_m under different ambient conditions for assurance of optimal operative efficacies and equipment life span. Therefore, recovery rate r should be maintained at a rate not exceeding the recommended recover rate r_m:

[67] $r \leq r_m$

[68]   Or,

[69] $r = B \cdot r_m$ [9]

[70]   where B represents a preconfigured factor mathematically describing variables affecting recovery rate r in a temperature drive operation . Substituting equations [6] and [9] into equation [7] :

[71] $T_{sb} = T_{set} - (\alpha \cdot \Delta t_a) / (B \cdot r_m)$ [10]

[72]   setback indoor temperature T_{sb} of a space using lead time period Δt_a , is yielded.

[73]   These drift and drive parameters are used in the method s of the invention for determining the corresponding setback temperature T_{sb} , as shown in flow chart **500** of FIG .5 . Typically, application server **110** determines the values of setback temperature T_{sb} in the unoccupied rented room, while receiving different location related information pertaining to mobile device **103**. I t is realized that application server **110** receives information encompassing whether the rented room status is unoccupied, from a separate system.

[74]   At step **510**, application server **110** periodically receives data pertaining to the rented room from control station **120**, including setpoint temperature T_{set} , i ndoor temperature $T(t)$ and ambient temperature T_{amb} , and stores the data in memory means **111** for mathematical establishment of thermal drift & drive relationships as illustrated in an exemplary graphical form in FIG.4 . It is worthwhile to point out that the objective conditions - such as ambient temperature T_{amb} - are continuously changing; said thermal drift & drive relationships are on a continually updated mathematical platform that affects the calculated results.

[75]   In one embodiment, a user carrying mobile device **103** departs from the rented room. At step **520**, application server **110** receives the proximity log from mobile device **103** carried by the user of the rented room - said information including but not limited to indicating the operative environment for tracking mobile device **103** being outdoor or indoor based. At the same time, application server **110** determines if the rented room is unoccupied on basis of information received from at least one other communicatively connected system. Application server **110** analyzes the proximity log and ends the process if the rented room status is identified as 'checked-out'. Conversely, application server **110** projects the time at which the user will return to the rented room and de-

termines a corresponding setback indoor temperature T_{sb} , on basis of archived numerical thermal drift and drive data. The process proceeds to step **530.**

[76]   Referring to FIG.2B, application server **110** receives the proximity log from mobile device **103** corresponding to the first position **261** recorded at the first instantaneous time t_1, and determines the value of d_1 (traversal distance between first position **261** and central point **251**). At step **530**, application server **110** - in one embodiment - uses a preconfigured value of lead time period Δt_{a1} on basis of position **261** being outside geo-fenced area **253**, and calculates the corresponding recovery time period Δt_{r1} , using equation [6]. Application server **110** extrapolates the corresponding setback indoor temperature T_{sb1}, based on the temperature responses in a drift process and drive process of the rented room as shown in FIG.4. Alternatively, application server **110** calculates setback temperature T_{sb1} by using equation [10]. At step **540**, application server **110** sends data pertaining to setback temperature T_{sb1} to control station **120**, for controlling HVAC system of environmental attribute means **130** in maintaining temperature of the rented room at a less energy demanding setback temperature T_{sb1}. The process returns to step **510.**

[77]   In a further embodiment, application server **110** receives the proximity log from mobile device **103** corresponding to the second position **262** recorded at the second instantaneous time t_2, and determines the value of d_2 (traversal distance between second position **262** and central point **25 1**). At step **530**, application server **110** calculates the user's velocity of travel v, using equation [2]:

[78] $v = (d_2 - d_1) / (t_2 - t_1)$ [2]

[79]   substituting velocity v into equation [1] to yield lead time period Δt_{a2} , application server **110** calculates the corresponding recovery time period Δt_{r2} , using equation [6].

[80]   Application server **110** extrapolates the corresponding setback indoor temperature T_{sb2} , based on the temperature responses in a drift process and drive process of the rented room as shown in FIG.4. Alternatively, application server **110** calculates setback temperature T_{sb2} by using equation [10]. At step **540** , application server **110** sends data pertaining to setback temperature T_{sb2} to control station **120**. Control station **120** initiates HVAC system of environmental attribute means **130** for adjusting indoor temperature T (t) from s etback temperature T_{sb1} to setback temperature T_{sb2} . Setback temperature T_{sb2} will be driven to setpoint temperature T_{set} within recovery time period Δt_{r2} .

[81]   Provision of Heated Water and Services

[82]   In another aspect of the invention, the tracking system is applied to projection of the total number of tracked users at the hotel with respect to time. Having obtained each tracked user's time of departing, and time of arriving at the hotel in accordance with the user's proximity log, yields the estimated number of total users at the hotel during any

time of the day. In furtherance, the settings of the temperature and the reserve volume in the hotel water heater system of environmental attribute means **130** can be projected.

[83]   The hotel's daily heated water consumption pattern is a function of the number of users and time, whereas, controls in heated water supply apply to the water flow, as well as, the heat flow. FIG.6A illustrates the heated water consumption rate on a typical day at a hotel having an occupancy rate of 70% in an exemplary profile **600**: recorded peaks exist between 6 a.m. - 7 a.m. (90% - 100% users on-site), 12 p.m. - 1 p.m. (30% - 45% users on-site), and 7 p.m.- 8 p.m. (60 - 80% users on-site).

[84]   An exemplary profile **601** in FIG.6B depicts the heated water consumption rate on an average day at a hotel with a 90% occupancy rate; wherein recorded data is available up to the concurrent time at 9:30 a.m. The typical historic records stored in memory means **111** (FIG.1) including but not limited to the archived profile **600**, and the projected number of users at the hotel, are attributes to establishing profile **601**. The first recorded peak **601-1** exists between 6 a.m.- 7 a.m. (90 - 100% users on-site).

[85]   In one embodiment, application server **110** projects the total number of users at the hotel at any time, by subtracting each departed tracked user with respect to the recorded departure time, and adding an arriving tracked user with respect to the projected arrival time at the hotel, in addition to an estimated number of residing untracked users. The typical per user consumption rate of heated water at peak demand is 45 liter/hour, whereas a typical daily per user consumption of heated water at 60 - 160 liters. The projection on heated water consumption rate may be segregated into 9:30 a.m.- 1:30 p.m. with a prime accuracy within 4 hours from concurrent time, and at a secondary accuracy from 1:30 p.m.- 12 a.m. The projected peak **601-2** at 12 p.m.- 1 p.m. and projected peak **601-3** at 7 p.m.- 9 p.m. are shown in profile **601**, which is con-tinually amended with most recently recorded and calculated lead time period Δt_a pertinent to each tracked user.

[86]   In yet another embodiment, application server **110** calculates the required volume of heated water in a storage tank type water heater at setpoint temperature, typically between 48°C to 60°C, which is readily for use. Energy conservation may be achieved by consistently maintaining a minimal 30 liter per user of heated water volume, or V, at setpoint temperature. The total required heated water volume in storage at any time, V_{tot}, can be found:

[87] $V_{tot} = n \cdot V$ [11]

[88]   where n is total number of users at the hotel.

[89]   The heated water consumption ΔV within a time period Δt can be sought, using the following equation:

[90] $\Delta V = n \cdot Q \cdot \Delta t$ [12]

[91]   where Q is the per user flow rate of heated water use.

[92]   Application server **110** continually projects the total number of users n, for establishment of a database pertaining to profile **601**. At step **540** of FIG.5, application server **110** transports the related information to one or more separate systems, which includes at least one of control station **120** , and water heater system of environmental attribute means **130** .

[93]   Resource Allocation and Service Provision

[94]   The tracking system of the invention also applies to human resources allocation in hotelier operations. Referring to FIG.7A, table 700 is an exemplary dynamic schedule indicating priority in providing housekeeping services in a five storey hotel. This schedule can be displayed via a communicatively connected device, including but not limited to mobile device **103**, and thin client **113** (FIG.1)

[95]   Slot **701**shows the clocktime used by the tracking system. Slot **702** indicates different states of a rented room. Application server **110**receives a message from a separate, communicatively connected system indicating the status of each hotel room as 'not rented', 'unoccupied', etc. Referring to FIG.2A, the lead time period Δt_a of a user pertaining to a rented room at center-of-mass **201** is determined on the basis of a single geo-fence boundary **204** with geo-fenced area **203** pertaining to 20 minute traffic time. The lead time period Δt_a relating to the time period before the user returns to c enter-of-mass **201** is determined at '20 minutes', given the tracked user location is within the geo-fenced area. The lead time period Δt_a is suggested at '20 minutes+' otherwise. Application server **110**changes the lead time period Δt_a related to each unoccupied rented room in table **700** in accordance with the periodically updated proximity log of the corresponding tracked user. The housekeeping staff can prioritize the unoccupied rented rooms to be serviced; and change the room status through said communicatively connected device as 'room cleaned', upon completion of the housekeeping task.

[96]   House Watching a Monitored Space

[97]   The tracking system of the invention house watches a monitored space in accordance with the continually updated attributes, as well as, proximity logs of one or more mobile devices **103** carried by the related tracked users. In one aspect, the tracking system determines the security status, and the operative modes of a plurality ofdevices **140** within or related to a monitored house, in accordance with an exemplary process **750** in FIG.7B.

[98]   Referring to FIG.1 , application server **110** determines whether one or more mobile devices **103** are within or outside the pertinent monitored house, in accordance with the corresponding proximity logs. At step **751** of process **750**, application server **110** periodically receives signal transmissions, including but not limited to data comprising the occupancy attribute from occupancy attribute means **150** pertaining to the monitored house , as well as, said one or more mobile devices **103**.

[99]   At step **752**, application server **110** analyzes the signal transmissions. In one embodiment, signal transmissions are disrupted or discontinued - application server **110** sends a probe signal to control station **120** via network **102**, and the response is incompliant with preconfigured parameters. At step **753**, application server **110** sends an alert to a third party, comprising at least one of the property management, security organization, mobile device **103**, and thin client **113**. In a contrary embodiment, signal transmissions incompliance between control station **120** and application server **110** are not experienced, process **750** proceeds to step **754**. Wherein, application server **110** analyzes said occupancy attribute.

[100]   In one embodiment, application server **110** determines that the house is 'occupied', or, application server **110** receives a message comprising change in said occupancy of the house; wherein, such change comprises a few aspects. In one exemplary aspect, device **140** comprising a door lock detects a visiting party's attempt to switch the locked state to unlocked state, and sends a corresponding signal to application server **110**.

[101]   At step **755**, application server **110** analyzes the proximity logs of said one or more mobile devices **103**. If application server **110** fails to verify the identities of occupants in the occupied house, or, the identity of said visiting party attempting to switch the locked state to the unlocked state of a door lock pertinent to the unoccupied house, an alert is sent to said third party in accordance with step **753**. In a different embodiment, the identities of occupants are verified, alternatively, the identity of said visiting party is verified. In a further embodiment, application server **110** determines in accordance with the proximity logs, one or more mobile device **103** are approaching the house within a close proximity threshold. Process **750** proceeds to step **756**.

[102]   At step **756**, application server **110** distinguishes said verified occupants, or verified said visiting party, or verified said approaching one or more mobile device **103**, by analyzing the identifiers and the corresponding proximity logs. In accordance with the results of identity distinguishment, application server **110**sends one or more signals for receipt by said plurality of devices **140** to change the operative mode from an 'unattended state' to a 'user configuredstate', or, from an 'unattended state' to a 'management state'. In one embodiment, application server **110** receives the audit trail from a door lock pertaining to device **140**, records in memory means **111** (FIG.1) and sends to said third party time-in and time-out of all entries and exits, in accordance with the results of identity verification and distinguishment.

[103]   In an alternative embodiment, application server **110**determines that the monitored house is 'unoccupied'. At step **757**, application server **110**sends to control station **120**, one or more signals for receipt by a plurality of devices **140**, to change the operative mode to an 'unattended state'. Process **750** proceeds to step **758**.

[104]   At step **758**, application server **110** determines if there is change, including but not limited to the pertinence between said one or more mobile devices **103**, and said monitored house. In one embodiment, application server **110** determines no said change - process **750** returns to step **751**. In an alternative embodiment, application server **110** determines said change. In one exemplary aspect, the pertinence between said one or more mobile devices **103** and said house - being a lease - is discontinued upon check-out. Process **750** is ended.

[105]   Accordingly, while the present invention has been described herein in detail in relation to one or more preferred embodiments, it is to be understood that this disclosure is only illustrative and exemplary of the present invention and is made merely for the purpose of providing a full and enabling disclosure of the invention. The foregoing disclosure is not intended to be construed to limit the present invention or otherwise exclude any such other embodiments, adaptations, variations, modifications or equivalent arrangements, the present invention being limited only by the claims appended hereto and the equivalents thereof.

[106]

Mode for Invention

[107]   The invention relates to a tracking system that governs control of indoor climate and water supply reserve, operative modes of selected devices and sending of projected arrival time of related users of a monitored space.

Industrial Applicability

[108]   One aspect of the invention relates to energy optimization in a rented hotel room and a house, and to activate on-demand device operation.

[109]   In a further aspect, a schedule with dynamic data pertaining to projected time of user arriving at said monitored space enabling planning of provision of services and allocation of human resources.

[110]   In yet another aspect, the system enables security of said monitored space by generating and sending an alert upon detection of unidentified occupancy. And, the system enables communicatively connected devices to trigger alert while being opened/closed by unidentified user.

Sequence List Text

[111]   External Device - communicatively connected to the system, including but not limited to a door lock, a light fixture, a home appliance, a safe, etc.

[112]   Thin Client - a network linked electronic device with computing capacity, such as a microcomputer or a handheld personal digital assistant ('PDA'), etc.

[113]   Off Mode - power disconnection.

[114]   Operative Mode - a device with power connection operating at an unspecified level.

[115]   Management State - an operative mode of a device operating at configurations imposed by property management, including but not limited to reduced power consumption.

[116]   Unattended State - an operative mode of a device operating at different levels, comprising: reduced power consumption, including but not limited to 'sleep' mode and 'standby' mode; alternatively, a device is configured to set off an alarm if the physical state is changed, including but not limited to 'locked' to 'unlocked', 'closed' to 'open'; and, code/PIN entry for attempt of open or use.

[117]   User Configured State - an operative mode of a device performing at one or more user specified levels, selected from functions, security level, or power consumption.

CLAIMS:

1.   A method for controlling an environmental attribute of a monitored space with an application server having an established drift and drive relationship where drifting the environmental attribute and driving the environmental attribute represent not operating and operating, respectively, an environmental attribute means, including, if the monitored space is unoccupied, a time of arrival of a user of a mobile device at a geographic location in relation to the monitored space, the method comprising:

defining a geo-fence area wherein the monitored space is located;

sending a present geographic location or proximity log of the mobile device to the application server;

projecting the time of arrival of the user at the monitored space on the basis of the present geographic location or proximity log of the mobile device; and

determining a setback recovery time period in accordance with the established drift and drive relationship, wherein the time of arrival at the monitored space of the user of the mobile device corresponds with the setback recovery time period.

2.   The method of claim 1, further including determining a setback level of an environmental attribute, or setback attribute;

executing a program having instructions stored in the memory means of the application server communicatively connected to an environmental attribute means;

receiving, from the environmental attribute means in accordance with sent operating parameters, the environmental attribute pertaining to the monitored space, and further processing data, including a predetermined setpoint, a predetermined maximum range relative to the setpoint, a first drift relationship, and a first drive relationship;

establishing a first drift relationship by drifting with respect to time the attribute from the setpoint, to the maximum range relative to the setpoint; and

drifting with respect to time at least one intermediate attribute between the setpoint, and the maximum range relative to the setpoint, to the maximum range relative to the setpoint;

establishing a first drive relationship by driving with respect to time the attribute from the maximum range relative to the setpoint, to the setpoint; and

driving with respect to time the at least one intermediate attribute between the setpoint, and the maximum range relative to the set point, to the setpoint;

storing in the memory means at least one drive relationship and at least one drift relationship; and

determining whether the at least one monitored space is occupied.

3. The method of claim 2, wherein:

the monitored space representing an independently located space that includes at least one of independently segregated and monitored minimal space, which is selected from a group including a hotel, a house, and a commercial building;

the setpoint is a predetermined level of the environmental attribute;

the maximum range is mathematically determined; or,

the maximum range is empirically determined - the maximum range is obtained when the monitored space is unoccupied, by a sensor that monitors the environmental attribute and provides data to the application server, wherein the environmental attribute in the monitored space is allowed to drift towards an ambient level of said environmental attribute in a region adjacent to the monitored space.

4. The method of claim 2, wherein:

the environmental attribute of the monitored space is indoor temperature; and

the environmental attribute means includes a temperature sensor, and at least one of a heating unit, an air conditioning unit and a ventilating unit.

5. The method of claim 2, wherein:

the environmental attribute of the monitored space is humidity; and

the environmental attribute means includes a humidity sensor, and at least one of a humidifier and a dehumidifier.

6. The method of claim 2, further comprising drifting an environmental attribute, representing reducing the environmental attribute by consumption, driving an environmental attribute representing increasing the environmental attribute, including the additional steps of:

determining the proximity logs pertaining to tracked mobile devices carried by the total number of users, concurrently comprising non-traversing users located in the monitored space pertaining to null proximities, as well as, traversing users projected to arrive in the monitored space in accordance with the corresponding proximity logs;

determining with respect to time the projected number of non-traversing users located in the monitored space, including determining in accordance with the proximity logs the corresponding number of traversing users arriving in the monitored space;

calculating with respect to time the setback attribute by multiplying the projected number of non-traversing users with a predefined unitary attribute quantity;

determining in accordance with at least one established drift relationship, the ratio with respect to time between the drifted attribute and the number of non-traversing users; and

sending the setback attribute with respect to time, and the ratio with respect to time, to a control unit of the environmental attribute means.

7.   The method of claim 2, wherein:

the monitored space representing an independently located space encompassing at least one independently segregated and monitored minimal space, which is selected from a group including a hotel, a house, and a commercial building;

the setpoint, representing the predefined unitary attribute quantity multiplied by the total number of users; and

the maximum range is empirically determined - the maximum range is measured if the attribute is allowed to drift towards a level, within a given time span, comprising the largest difference with the setpoint.

8.   The method of claim 2, wherein:

the environmental attribute of the monitored space is the heated water reserve quantity at a predetermined temperature;

the predefined unitary attribute quantity is the heated water reserve quantity at the predetermined temperature readily supplied for one user of the total number of users; and

the environmental attribute means includes at least one of a sensor for measuring the volume of the attribute in a storage tank, and a water heating unit.

9.   The method of claim 1, further comprising:

monitoring the level of the environmental attribute of the monitored space;

sending a detected level of the environmental attribute to the application server;

determining a setback attribute, which is to be driven to a setpoint within the setback recovery time period, in accordance with the established drift and drive relationship;

sending the setback attribute to a control unit or environmental attribute means;

allowing the environmental attribute in the monitored space to drift to the setback attribute level when the monitored space is unoccupied; and,

driving the environmental attribute at the setback attribute level so the environmental attribute proceeds toward the setpoint within a time period relating to a time of arrival of the user at the monitored space.

10.   The method of claim 1, further comprising calculating the time of arrival based on a velocity of the mobile device in change of geographic location.

11.   The method of claim 1, further comprising altering the geo-fence area in accordance with preconditioning factors pertaining to selected traffic conditions, time, and characteristics of the user and the mobile device.

12.   The method of claim 1, further comprising preconfiguring the time of arrival as one preconfigured value when the present geographic location of the mobile device is within the geo-fence area, and as another preconfigured value when the present geographic location of the mobile device is outside of the geo-fence area.

13.   The method of claim 1, further comprising using the mobile device to send a manually entered arrival time to the application server.

14.   The method of claim 1, in which the monitored space is a guest room in a hotel, a house, or an office unit in a commercial building.

15.   The method of claim 1, further comprising recording the time in which the setback attribute is established, geographical location of the user, and estimating a lead time period for the user at the determined geographical location to arrive at the monitored space.

16.   The method of claim 1, further comprising detecting the geographical position of the user, estimating a time period required by the user at the determined geographical position to arrive at the monitored space.

17.   The method of claim 1, further comprising having the time of arrival correspond with the lapse of the setback recovery time period.

18.   The method claim 2, wherein the environmental attribute of the monitored space is a temperature of heated water in a water heating unit, and the method includes sensing the temperature of the water in the water heating unit with a temperature sensor.

19.   A system for controlling an environmental attribute of a monitored space, the system comprising:

an application server having an established drift and drive relationship where drifting the environmental attribute and driving the environmental attribute represent not operating and operating, respectively;

an environmental attribute means in operative communication with the application server, and including an indication of whether the monitored space is unoccupied; and

a mobile device in communication with the application server to provide a geographic location in relation to the monitored space and send a present geographic location or proximity log of the mobile device to the application server whereby the application server unit projects the time of arrival of a user at the monitored space on the basis of the present geographic location or proximity log of the mobile device, and further determines a setback recovery time period in accordance with the established drift and drive relationship so that the time of arrival at the monitored space of the user of the mobile device corresponds to the setback recovery time period.

20.   The system of claim 19, further comprising a sensor that monitors the environmental attribute and provides data to the application server regarding same.

21.   The system of claim 20, wherein the sensor is a temperature sensor to monitor a temperature of the monitored space.

22.   The system of claim 20, wherein the application server is operatively connected to a control unit to establish a setback temperature for the monitored space.

23.   The system of claim 20, wherein the application server includes data stored therein.

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SPRUSON & FERGUSON

FIG. 1

100

101
geo-location
system

---- 108

| 104 | | 105 |

| | 106 |

103 mobile device

---- 107

112
beacon

113
thin client

102
communications
network

110
application
server

120
control station

130
environmental
attribute means

140
device

111
memory
means

150
occupancy
attribute means
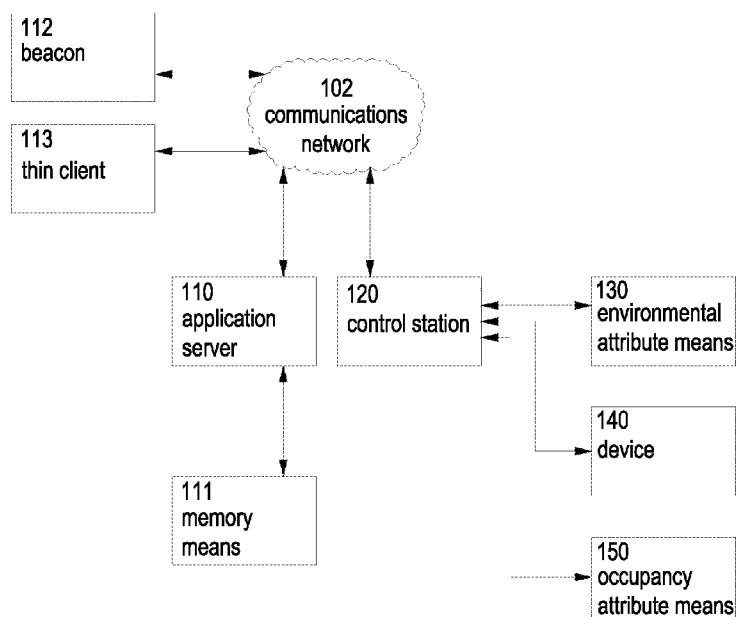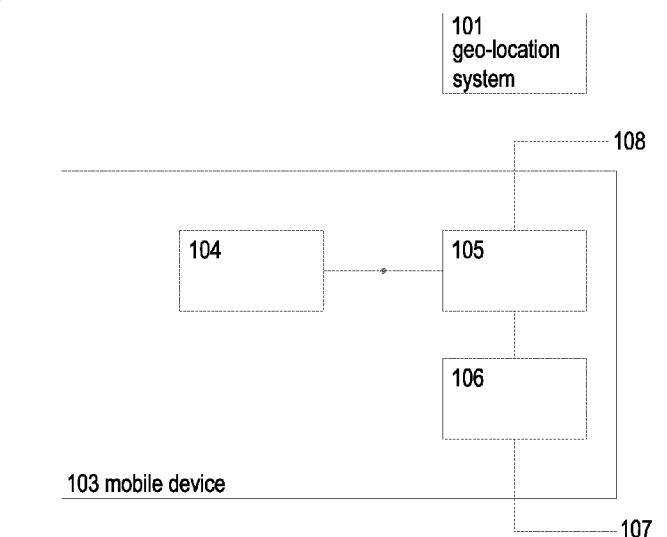
FIG. 2A
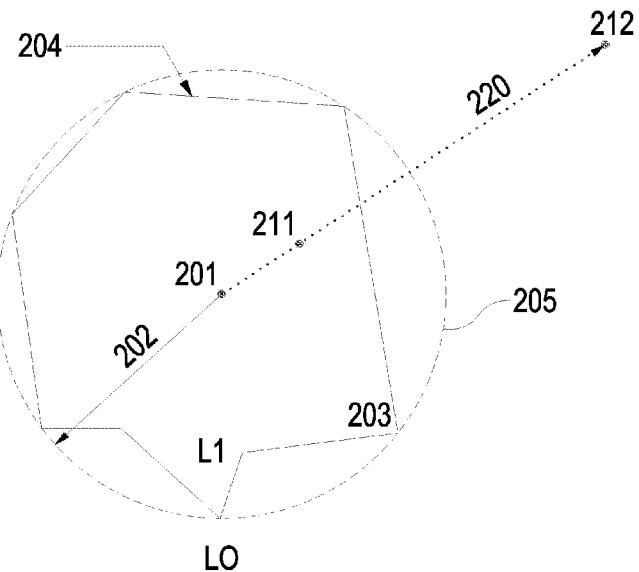
FIG. 2B
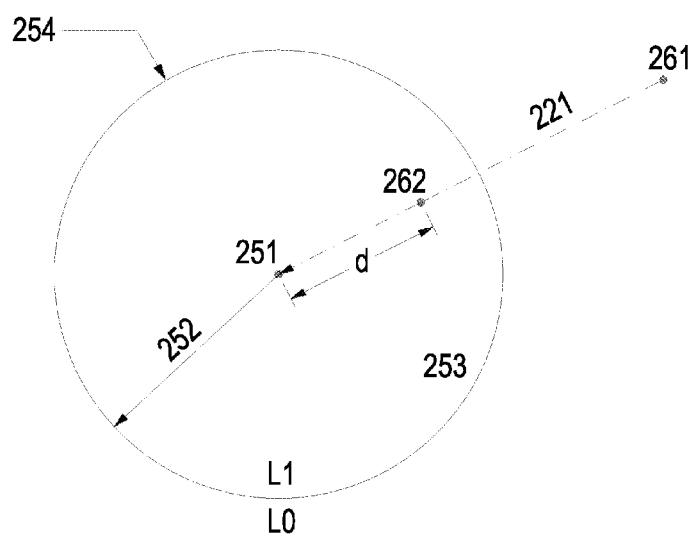
FIG. 3
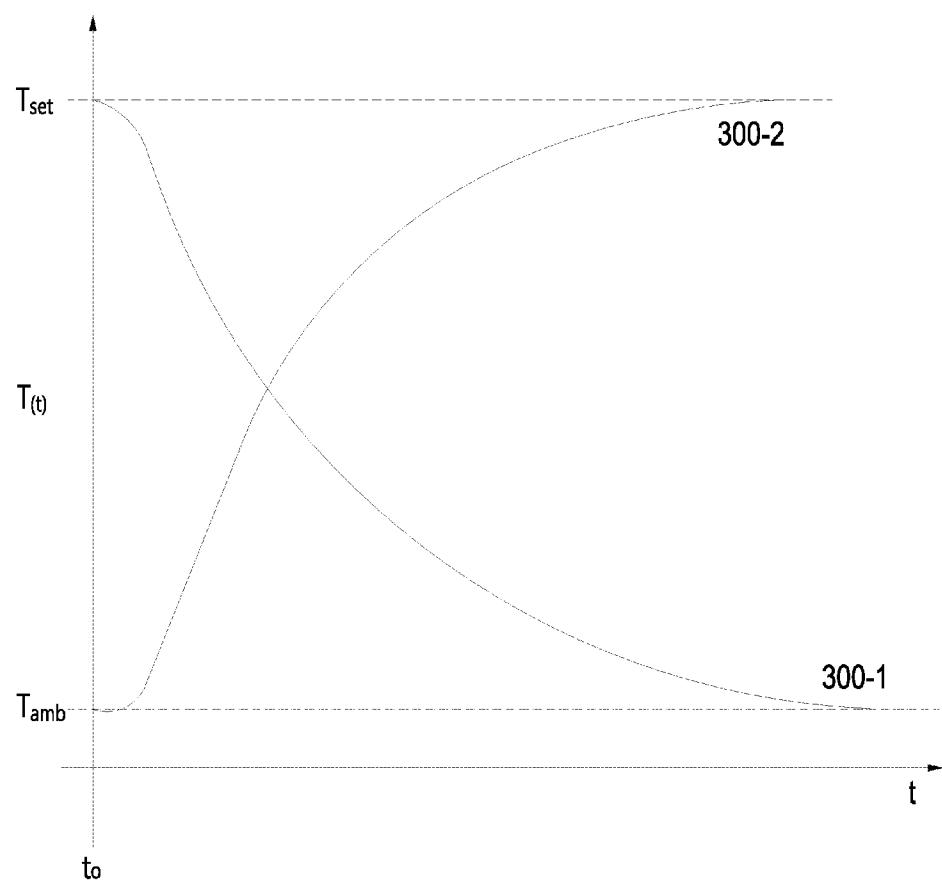
FIG. 4
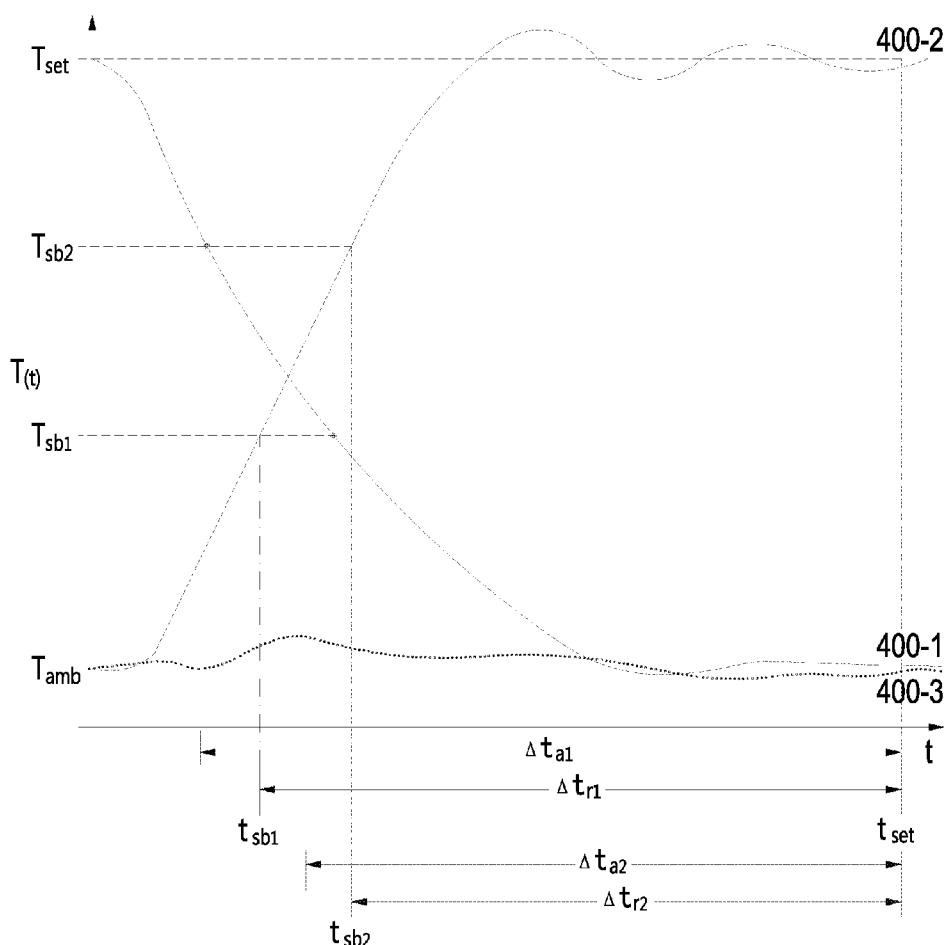
FIG. 5
500
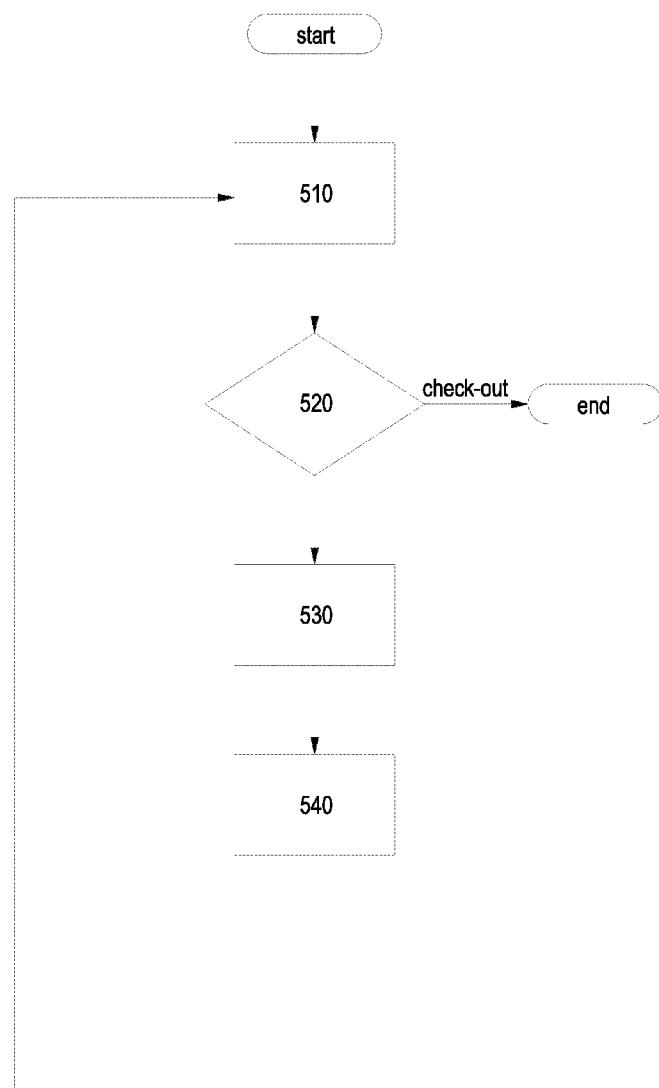
FIG. 6A
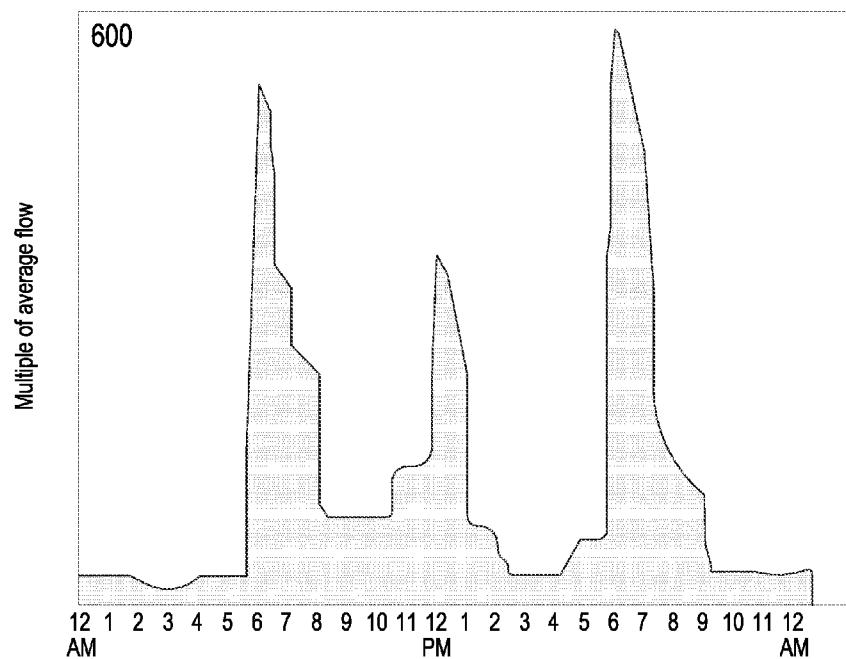
FIG. 6B

FIG. 7A
700

701

09:30 a.m.

	501	502	503	504	505
LEVEL 5	⬤ tenant in room	Δta = 20 min	Δta = 20 min	⬤ tenant in room	✓ room cleaned
	401	402	403	404	405
LEVEL 4	Δta = 20 min	Δta = 20 min	Δta = 20 min +	Δta = 20 min +	Δta = 20 min +
	301	302	303	304	305
LEVEL 3	✓ room cleaned	✓ room cleaned	Δta = 20 min	⬤ tenant in room	not rented
	201	202	203	204	205
LEVEL 2	⬤ tenant in room	not rented	not rented	Δta = 20 min	not rented
	101	102	103	104	105
LEVEL 1	not rented	not rented	not rented	Δta = 20 min	✓ room cleaned

702

▨   not rented

Δta = 20 min + (tenant outside 20 minutes geo-fence)

Δta = 20 min (tenant within 20 minutes from hotel)

✓   room cleaned

⬤   tenant in room

FIG. 7B
750